



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Programme of Study : Ph.D.

Thesis Title: Development of activated carbon-supported bimetallic catalysts and microreactors for the production of lactic acid, 2,5-furandicarboxylic acid, and 5-hydroxymethylfurfural

Name of Thesis Supervisor(s) : Prof. Nageswara Rao Peela and Prof. V. S. Ramagopal Uppaluri

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Key words for description of Thesis : 5-Hydroxymethylfurfural; Fructose; Helical coil
Work microreactor; Bronsted acid; 2,5-furandicarboxylic acid (FDCA); Base-free oxidation, Ru-V bimetallic catalysts; Glycerol, Lactic acid, Selective Oxidation, Activated carbon catalyst support, Pt-V bimetallic catalysts.

SHORT ABSTRACT

Essential biomass-derived platform chemicals such as lactic acid, 5-hydroxymethylfurfural (HMF), and 2,5-furandicarboxylic acid (FDCA) hold significant potential in the polymer and fine chemical industries. This study focuses on catalytic transformations: glycerol to lactic acid and HMF to FDCA, employing activated carbon-supported bimetallic catalytic systems, and fructose to HMF, using homogeneous catalysts in helical coiled reactors.

The study explored HMF production via fructose dehydration in helical coil microreactors (HCMR) using homogeneous catalysts (H₂SO₄ and maleic acid). This approach demonstrated enhanced reactor throughput, yielding a notable HMF space-time yield of 380 gHMF/gCat/h.

Maleic acid showed superior selectivity (83%) to HMF with reduced degradation compared to sulfuric acid (80%). For FDCA synthesis by HMF oxidation, activated carbon-supported Ru-V and Ru-Ni catalysts were developed under base-free aqueous conditions. Optimized conditions achieved a 74.4% FDCA yield with complete HMF conversion using Ru-V/AC and a 65.3% yield using Ru-Ni/AC. Catalyst regeneration was accomplished with a simple acetone wash, which removed humins and restored activity. Characterization of the catalysts employed techniques such as powder X-ray diffraction (p-XRD), N₂-sorption, FETEM, HRTEM, EDX, and XPS, providing insights into their structural and chemical properties. Finally, an alternative method for lactic acid production via selective glycerol oxidation was investigated. Monometallic Pt, Ru, V, and bimetallic Pt-V and Ru-V catalysts supported on AC were tested for this reaction. The Ru-V/AC catalyst demonstrated higher yields (79.62% and 75.53%, respectively) and complete glycerol conversion under optimized conditions, highlighting its effectiveness and stability.

Keywords: 5-Hydroxymethylfurfural; Fructose; Helical coil microreactor; Bronsted acid; 2,5-furandicarboxylic acid (FDCA); bimetallic catalysts; Glycerol, Lactic acid, Selective Oxidation, Activated carbon catalyst support